REMARKS:

The present Amendment makes editorial changes in the title, specification and claims, and adds an Abstract to conform the present PCT application to the requirements of United States patent practice. The cancellation of claims 1-12 in favor of the claims presented herein has been done solely because the amount of strikethroughs and underlining in original claims 1-12 that would have been necessary to confirm those claims to the requirements of United States patent practice would have been unduly burdensome and confusing. No change in the claim language has been made for the purpose of distinguishing any of the present claims over the teachings of the prior art of record. Accordingly, no difference in the claim language between the present claims and original claims 1-12 is considered by the Applicants as a surrender of any of the subject matter encompassed within the scope of original claims 1-12.

Early consideration of the application on the merits is respectfully requested.

Submitted by,

Steven H. Noll (Reg. 28,982)

Schiff, Hardin LLP
CUSTOMER NO. 26574
Patent Department
6600 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606
Telephone: 312/258-5790
Attorneys for Applicant(s).

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~~Description~~

~~MRI MAGNET DEVICE WITH AXIALLY ADJUSTABLE ROSE SHIM RING~~

~~(1) Technical field~~

SPECIFICATION

TITLE

"SHIMMING STRUCTURE AND METHOD FOR A MAGNETIC RESONANCE IMAGING APPARATUS"

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method ~~of~~ for adjusting the static magnetic field in ~~the~~ a magnetic resonance imaging (MRI) device ~~or Nuclear Magnetic Resonance (NMR) device~~ and a static magnetic field generating apparatus that ~~could generate~~ generates a higher field strength. The ~~principle of the~~ present invention can be used in ~~will be illustrated by taking~~ a C-type magnet ~~in the~~ of a magnetic resonance imaging apparatus ~~equipment as an example~~, but ~~the present invention~~ is ~~not only applicable to magnetic resonance magnet, but~~ also ~~to nuclear magnetic resonance magnet and~~ suitable for use in other devices using an electro-magnet to generate a uniform static magnetic field ~~and the shape of the magnet is also not limited~~, without limitation to the exemplified C-type.

~~(2) Background Art~~

Description of the Prior Art

In the early ~~days when the permanent magnet is used in~~ development of magnetic resonance imaging equipment for commercial use, the field strength of the permanent magnet was usually lower than 0.25T. In the 1990's, magnetic resonance imaging equipment for commercial use were developed that ~~employ~~ employed a permanent magnet ~~appeared~~ with a field strength of 0.3T and the performance thereof was better, the cost was reasonable and the structure was compact. The greater the field strength ~~is~~, the higher the signal-to-noise ratio ~~is~~,

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and the better the quality of the image generated by the permanent magnet magnetic resonance equipment. In recent years, the field strength of some of the permanent magnets ~~could even~~ can reach 0.35T-0.4T.

At present, ~~some~~ certain problems exist in the manufacturing of a magnet with a higher field strength~~, they are~~ such as:

I. Permanent magnets having a field strength greater than 0.3T and with high homogeneous magnetic field in the scanning area are expensive, large in volume and heavy in weight (heavier than 17 tons) and need a large area for installation, and thus ~~these defects~~ have limited ~~its~~ application in ~~the~~ magnetic resonance equipment.

II. Since a uniform strong magnetic field is to be generated, the size of the pole plates ~~are~~ usually is large, thus the open angle between the two pole plates will inevitably be limited and this is a problem for patients ~~of~~ subject to claustrophobia.

III. The magnet needs shimming or repairing during its installation and use, or re-shimming is required when service and thus the gradient coil and transmitting coil have to be removed, which is time-consuming and expensive.

IV. Due to manufacturing tolerances, magnets of the same design may have different field strengths ~~strength~~, thus volume production of the same RF coils and the systems ~~become~~ becomes very difficult and ~~thereby~~ the costs for the corresponding system of the whole magnetic resonance equipment increase.

~~With respect to~~ To address the above problems, the following methods are conventionally ~~usually~~ employed:

I. ~~In order to~~ To increase the field strength and improve the field homogeneity ~~uniformity thereof~~, ~~the method generally adopted is to increase~~ but this increases the volume and size of both the permanent magnet and the pole

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plate, which will increase the cost as well as the volume and weight of the magnet.

II. The ~~uniformity~~ homogeneity of the magnetic field is improved by employing a Rose ring but when the field strength is over 0.3T, the magnetic field ~~uniformity~~ homogeneity of the permanent ~~for the~~ obtaining a magnetic resonance image of the whole human body becomes worse and a single Rose ring cannot ensure the ~~uniformity~~ homogeneity of the field ~~strength~~.

III. Permanent magnets that ~~could~~ reduce magnetic flux leakage are employed to compensate for the field strength leakage in the external edge of the pole plate, but ~~said method~~ this increases the size of the external edge of the magnet pole plate and reduces the open angle between the pole plates, and ~~meanwhile, it~~ furthermore requires complicated manufacturing process and hence increases the cost.

IV. Field strength adjusting and fine adjusting structures are employed, but these mechanisms are complex in ~~designs~~ design and expensive.

Moreover, the effects achieved by all of these known methods ~~in the prior art~~ are still not satisfactory.

~~(3) Contents of the invention~~

SUMMARY OF THE INVENTION

~~Therefore, the~~ The method and apparatus ~~in~~ of the present invention ~~adopts~~ employ the following ~~measures~~ features to overcome the ~~technical defects existing~~ aforementioned disadvantages in the prior art.

I. Employing another adjusting shimming ring (the second type of Rose ring) without increasing the size of the pole plate to improve the uniformity of the magnetic field while not reducing the open angle between the pole plates. ~~Meanwhile, said~~ The additional shimming ring (the second type of Rose

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ring) has a variable distance with respect to the first type of Rose ring so as to change the magnetic path and adjust the uniformity of the magnetic field.

II. Distribute permanent magnetic materials having different magnetic energy levels in special manners so as to improve the ~~uniformity~~ homogeneity of the magnetic field and reduce the cost.

III. Three methods are employed in the present invention to adjust the magnetic field strength and shimming. One is adjusting and shimming the static magnetic field by fine adjusting magnetic conducting bars or permanent magnetic bars installed on the external edge of the pole plate for example of the C-type magnet, so as to compensate for the inhomogeneous magnetic field caused by tolerances of magnet manufacturing and assembling; another is providing a magnetic conducting or permanent magnet bolt adjusting mechanism on the shimming Rose ring, and the magnetic path is changed by adjusting the position of the bolt so as to adjust the magnetic field; the other method is changing the magnetic path by changing the position of the second type of shimming ring with respect to the first type of Rose ring as mentioned in method ~~one~~, and thereby ~~to adjust~~ adjusting the magnetic field. The ~~joint~~ combined application of ~~said~~ these three methods will achieve a large range of adjustment and is easy in operation. Hence, the inhomogeneity caused by the tolerances of manufacturing and assembling is compensated and the field strength of the permanent magnet is made uniform.

Further, the method and apparatus of the present invention use the above-mentioned two or three methods jointly to achieve better shimming effect.

In the prior art, the Rose shimming ring ~~(5)~~ is provided at the external edges on the horizontal plane of the pole plates of both the upper and lower poles, but the shimming effect achieved by a single pair of shimming rings is not satisfactory. Due to the characteristics of the structure of the permanent magnet, the magnetic field strength at the edge of the pole plate is relatively weak, which is

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especially serious when the field strength is over 0.3T, thus single shimming ring cannot fully compensate the inhomogeneity of the magnetic field. The present invention improves the design and fixing manner of the gradient coil and the transmitting coil. Taking the upper pole plate shimming ring as an example, an additional shimming ring (the second type of Rose ring) ~~(6)~~ with adjustable distance to the shimming ring ~~(5)~~ is employed at the external edge of the lower end of the first shimming ring ~~(5)~~ to change the ~~uniformity~~ homogeneity of the magnetic field and a corresponding shimming adjusting mechanism is provided. Similarly, the second type of shimming ring the spacing of which from ~~(6) whose distance with to~~ the first shimming Rose ring ~~(5)~~ is adjustable, is also employed at the corresponding position on the lower pole plate.

~~With respect to the defects~~ To address the aforementioned disadvantages in the prior art, the present invention provides a static magnetic field generating apparatus in the magnetic resonance equipment~~; it comprises~~ having a permanent magnet magnetic field source ~~(1)~~, and a C-type yoke or a ~~multi-posts~~ multipart supporting structure that ~~constitutes~~ forms the magnetic path. The ~~examination subject measured body~~ is positioned in the space between the two opposite end faces of the permanent magnet magnetic field source ~~(1),~~ ~~wherein the said~~ The two opposite end faces are mirror symmetrical ~~by~~ with respect to the virtual plane between the two faces[[;]]. Pole plates ~~(2)~~ are placed on each of the opposite end faces. The structure is symmetrical with respect to the virtual middle plane but ~~for the illustration purpose~~, ~~take~~ in the upper half for example, pole pieces ~~(4)~~ are ~~employed~~ disposed beneath the aforementioned pole plate, a gradient coil is ~~employed~~ disposed beneath the pole piece ~~(4)~~, an RF transmitting coil ~~(8)~~ is ~~employed~~ disposed beneath gradient coil ~~(7)~~, a first shimming ring ~~(5)~~ is employed outside the gradient coil. Each ~~(7); each~~ pair of ~~the~~ pole plates ~~(2)~~, pole pieces ~~(4)~~, gradient coils ~~(7)~~, RF transmitting coils ~~(8)~~ and the first shimming rings ~~(5)~~ are substantially mirror symmetrical with respect to the virtual plane between the two opposite end faces. An additional second shimming ring ~~(6)~~ is employed on the external edge of the each of the first shimming rings ~~(5)~~, and the second shimming ring ~~(6)~~ is symmetrical to the ~~above~~ aforementioned virtual plane, to ~~uniform~~

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homogenize the static magnetic field in the space, occupied by ~~of~~ the ~~measured body~~ examination subject.

According to the static magnetic field generating apparatus of the present invention, the outer faces of the additional upper and lower shimming rings ~~(6) which are facing~~ that force the examination subject do ~~measured body are essentially~~ not ~~projecting higher than~~ project beyond the outer plane of the RF transmitting coils so as to ~~keep~~ maintain the openness of the magnet.

Another solution for the static magnetic field generating apparatus of the present invention is ~~that said~~ to form the magnetic field source ~~is composed of a plural~~ with multiple groups of permanent magnetic columns of different magnetic energy levels~~, the~~. This distribution of magnetic energy ~~level of~~ levels in the columns can be axially symmetric with respect to the central axis through the pole center but perpendicular to the pole plane. The distribution of energy ~~level of~~ levels in the columns can also be symmetric with respect to one or more axis in the pole plane through the center point of the pole, for example, the left and right halves, and the front and back halves are symmetrical.

~~According to~~ In an embodiment of the static magnetic field generating apparatus of the present invention, ~~wherein~~ the permanent magnet magnetic field source is arranged in rings according to the magnetic energy levels. The number of rings ~~could~~ can be two, three or more. For example, when three rings are arranged, ~~said~~ the permanent magnet magnetic field source is divided into three ring areas according to the magnetic energy levels, wherein the magnetic energy level of the external ring area is N3, the magnetic energy level of the middle ring area is N2, and the magnetic energy level of the inner ring area is N1, and N3>N>N1.

~~Another solution~~ In another embodiment of the static magnetic field generating apparatus of the present invention ~~is providing a plurality~~ a number of magnetically ~~magnetic~~ conducting bolts or ~~permanent~~ permanently magnetic bolts ~~(11)~~ are arranged symmetrically with respect to axes in the pole plane. Those

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adjusting bolts are mounted on one or ~~a plurality~~ more of the parts of the pole plate ~~(2)~~, the ~~permanent~~ magnetic field source ~~(1)~~, the first shimming ring ~~(5) and~~ or the second shimming ring ~~(6)~~, so that the field strength of the static magnetic field is precisely adjusted.

In the prior art, the field strength at the edge of the magnet is usually lower than that at the center. Therefore, as a measure in the prior art, adding a first shimming ring ~~(5)~~ to the outer side of the gradient coil will increase the field strength at the edge~~. However, the inventor of the present application found~~, but the present invention is based on the finding that ~~only~~ using only a first shimming ring ~~(5)~~ will not achieve satisfactory effect. ~~Hence, as a part of~~ Thus, in accordance with the present invention, a second adjustable shimming ring ~~(6)~~ is added to the side of the first shimming ring ~~(5)~~ that faces the ~~measured body~~ examination subject and to the outer side of the gradient coil ~~(7)~~, and the ~~fixing~~ relation between the gradient coil and the transmitting coil is adjusted. For ~~the~~ volume production of the system, the manufacturing tolerances need to be considered.

According to the above-mentioned principle of the present invention, a shimming ring of different shape could be designed to replace the first shimming ring ~~(5)~~ and the second shimming ring ~~(6)~~.

In another embodiment ~~aspect~~, ~~in order to achieve~~ for shimming ~~of~~ to achieve higher homogeneity, the magnetic field profile has to be re-designed when designing the magnetic source assemblies of different magnetic energy levels. In this process, the factors that influence the field strength of the magnetic field should be considered, for example, manufacturing precision, deviation of the assembling position and even minor corner damage of the magnetic columns in the assembling process.

As a part of the present invention, for the adjusting bolts of ~~ferro-magnetic~~ ferromagnetic or permanent magnetic material, screw threads ~~could be made~~ are provided on many parts of the magnetic field generating apparatus, and the bolts

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are made ~~by~~ of magnetic materials that are the same ~~to~~ as or different from the materials of ~~said~~ the parts. Matching between the screw threads and the bolts is very important, because if they are too tight, a strong force has to be applied to the screw ~~rod~~ during adjustment ~~and~~ thus causing deformation or even ~~break~~ breakage of the bolts, but if they are ~~in~~ too loose ~~contact~~, ~~due to~~ the vibration caused by the ~~pulse~~ pulsed magnetic force~~, the~~ will cause the field strength ~~will be made~~ to become unstable ~~and~~ thus causing irregular changes of field strength.

~~According to the situations of~~ Dependent on the manufacturing conditions, ~~said~~ the additional shimming ring ~~(6)~~, the permanent magnetic field source ~~(1)~~ of different magnetic energy levels, and the adjusting bolts ~~(11)~~ of magnetic material of the present invention could be ~~applied~~ used jointly. For instance, the shimming effect could be achieved by using a second shimming ring ~~(6)~~ in combination with ~~permanent~~ permanently magnetic columns ~~(1)~~ of different magnetic energy levels, or by using the second shimming ring ~~(6)~~ in combination with fine adjustment by magnetic conducting bolts or permanent magnetic bolts ~~(11)~~. ~~Meanwhile, the~~ The shimming effect could also be achieved by adopting permanent magnetic columns ~~(1)~~ of different magnetic energy levels to form the magnetic field profile while combining the method of fine adjustment by magnetic bolts ~~(11)~~.

~~Or else~~ Alternatively, the shimming effect ~~could also~~ can be achieved by ~~adopting~~ using the second shimming ring ~~(6)~~, the magnetic source composed of permanent magnetic columns ~~(1)~~ of different magnetic energy levels and the fine adjustment by ~~magnetic~~ magnetically conducting bolts or ~~permanent~~ permanently magnetic bolts ~~(11)~~ at the same time.

The present invention also ~~discloses~~ includes a method ~~of~~ for adjusting the static magnetic field in magnetic resonance equipment, said magnetic resonance equipment ~~comprises~~ having a permanent magnet magnetic field source ~~(1)~~, a C-type yoke or a ~~multi-posts~~ multi-post supporting structure that ~~constitutes~~ forms the magnetic path[[;]], with the ~~measured body is~~ examination subject being positioned in the space between the two opposite end faces of the ~~permanent~~ permanently magnetic columns ~~(1), wherein the said~~. The two opposite end faces

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are mirror symmetrical ~~by~~ with respect to the virtual plane between the two faces[[;]]. Pole plates ~~(2)~~ are placed along the direction of the measured body on each of the opposite end faces~~; the~~. The structure is symmetrical with respect to the virtual middle plane ~~but for the illustration purpose, take~~. In the upper half for example, pole pieces ~~(4)~~ are ~~employed~~ disposed beneath the aforementioned pole plate, a gradient coil ~~(7)~~ is ~~employed~~ disposed beneath the pole piece ~~(4)~~, an RF transmitting coil ~~(8)~~ is ~~employed~~ disposed beneath the gradient coil ~~(7)~~, a first shimming ring ~~(5)~~ is ~~employed~~ disposed outside the gradient coil ~~(7); each~~. Each pair of ~~the~~ pole plates ~~(2)~~, pole pieces ~~(4)~~, gradient coils ~~(7)~~, RF transmitting coils ~~(8)~~ and ~~the~~ first shimming rings ~~(5)~~ are substantially mirror symmetrical with respect to the virtual plane between the two opposite end faces~~, characterized in that: an~~. An additional second shimming ring ~~(6)~~ is ~~employed~~ disposed on the external edge of the each of the first shimming rings ~~(5), and the~~. The second shimming ring ~~(6)~~ is symmetrical to the above virtual plane, to ~~uniform~~ homogenize the static magnetic field in the space of the measured body further~~; further~~, the permanent magnet magnetic field source is composed of a ~~plural~~ groups of permanent magnetic columns of different magnetic energy levels, so that the magnetic energy level of the permanent magnetic columns ~~further~~ farther from the center of the pole plate is higher than that of the permanent magnetic columns nearer ~~from~~ to the center of the pole plate, and ~~thereby~~ to improve the ~~uniformity~~ homogeneity of the magnetic field~~; and more further~~,. Further on the basis of the above-mentioned method, a ~~plurality~~ number of magnetic conducing bolts or permanent magnetic bolts ~~(11)~~ are employed symmetrically along the end face axis of the ~~permanent~~ permanently magnetic column ~~(1)~~ on the pole plate ~~(2)~~, or along the ~~permanent~~ permanently magnetic column ~~(1)~~, the first shimming ring ~~(5)~~ and the second shimming ring ~~(6), and by~~. By adjusting the positions of ~~said~~ the ~~magnetic inducing~~ magnetically conductive bolts or ~~permanent~~ permanently magnetic bolts ~~(11)~~, the field strength of the static magnetic field is adjusted.

~~Moreover, another~~ Another embodiment of the inventive method of adjusting the static magnetic field in MR equipment~~, said~~ is applicable to magnetic resonance equipment having a ~~comprises~~ permanent magnetic source ~~(1)~~, and a

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C-type yoke or a multipost ~~multiposts~~ supporting structure that ~~constitutes~~ forms the magnetic path. The ~~measured body~~ examination subject is positioned in the space between the two opposite end faces of the permanent magnetic source ~~(1)~~, ~~wherein~~ the ~~said~~ two opposite end faces ~~are~~ being mirror symmetrical with respect to the virtual plane between the two faces[[;]]. Pole plates ~~(2)~~ are ~~placed~~ disposed on each of the opposite end faces[[;]]. The structure is symmetrical with respect to the virtual middle plane~~; For the illustration purpose, take~~. In the upper half for example, pole pieces ~~(4)~~ are ~~employed~~ disposed beneath the ~~afore-mentioned~~ aforementioned pole plate, a gradient coil is ~~employed~~ disposed beneath the pole piece ~~(4)~~, an RF transmitting coil ~~(8)~~ is ~~employed~~ disposed beneath the gradient coil ~~(7)~~, a ~~first~~ shimming ring ~~(5)~~ is ~~employed~~ disposed outside the gradient coil ~~(7); each~~. Each pair of the pole plates ~~(2)~~, pole pieces ~~(4)~~, gradient coils ~~(7)~~, RF transmitting coils ~~(8)~~ and ~~the first~~ shimming rings ~~(5)~~ are substantially mirror symmetrical with respect to the virtual plane between the two opposite end faces~~;~~ ~~characterized in that : the~~. The permanent magnetic source ~~(1)~~ is composed of a ~~plural~~ multiple groups of permanent magnetic columns of different magnetic energy levels, so that the magnetic energy level of the permanent magnetic columns ~~further~~ farther from the center of the pole plate is higher than that of the permanent magnetic columns close to the center of the pole plate, ~~and~~ thereby ~~to~~ ~~improve~~ improving the uniformity of the magnetic field~~, and meanwhile, a plurality~~. A number of ~~magnetic conducing~~ magnetically conducting bolts or ~~permanent~~ permanently magnetic bolts ~~(11)~~ are employed symmetrically along the end face axis of the permanent magnetic source ~~(1)~~ on one or ~~a plurality~~ more of the parts in the ~~said pole plate (2), permanent magnetic source (1), first shimming ring (5) and the second shimming ring (6), and by adjusting the positions of the said magnetic conducing bolts or permanent magnetic bolts (11), the field strength of the static magnetic field is precisely adjusted~~ aforementioned mirror symmetrical arrangement.

~~(4) Description of figures~~

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~~The five figures of embodiments of the present invention further illustrate the principle of the present invention, wherein:~~

~~Fig. 1 shows the shimming rings on the upper and lower poles of the C-type magnet;~~

~~Fig. 2 shows the enlarged drawing of the part marked in a circle in Fig. 1;~~

~~Fig. 3 shows the method of adjusting field strength by using a plurality of magnetic conducting or permanent magnetic bolts;~~

~~Figs. 4 and 5 show the method of making the magnetic field more uniform by making different areas of the magnetic field to have different magnetic energy levels.~~

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a magnetic resonance imaging apparatus having a C-type magnet, constructed and shimmed in accordance with the principles of the present invention.

Fig. 2 is an enlargement of the circled portion of Fig. 1.

Fig. 3 illustrates an embodiment of a method for adjusting (shimming) the magnetic field strength in accordance with the invention, using a number of magnetically conducting or permanently magnetic bolts.

Fig. 5 is a side view, partly in section, of a further embodiment of a static magnetic field generator of a magnetic resonance imaging apparatus in accordance with the present invention, wherein the magnet is divided into columns respectively having different magnetic energy levels.

Fig. 5 is a sectional view of the apparatus of Fig. 4, in and plane proceeding perpendicularly to the vertical dot-dash axis shown in Fig. 4.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows ~~the~~ shimming rings of the upper and lower poles of ~~the~~ a C-type magnet. ~~In Fig. 1, component 9 is the~~ The apparatus has a press plate~~, component 10 is the~~ and a magnetic field generating source 10, having permanently ~~which comprises the permanent~~ magnetic columns 1 ~~(1)~~. A ~~plurality~~ number of ~~magnetic~~ magnetically conducting or ~~permanent~~ permanently magnetic bolts 11 are movable ~~(11) which could move~~ up and down ~~are shown in the~~ at external edge of the magnetic field source in Fig. 1 so as to achieve the above-mentioned adjustable effect.

Fig. 2 ~~is the enlarged drawing~~ is an enlargement of the ~~part~~ portion marked in a circle in Fig. 1, ~~wherein component 1 is~~ showing the permanent magnetic source 1, ~~component 2 is~~ the pole plate 2, ~~component 3 is~~ the pole plate 3 after cutting processing, ~~component 4 is the~~ another pole plate 4, ~~component 5 is~~ the first shimming ring 5, ~~component 6 is~~ the second shimming ring 6 with an adjusting means, ~~component 7 is~~ the gradient coil 7 and ~~component 8 is~~ the RF emitting coil 8. ~~It can be seen from Fig. 2 that a new~~ In accordance with the invention shimming ring ~~(6) is~~ 6 has been added in addition to the original shimming ring 5 ~~(5)~~. In Fig. 2, the outer diameter of the upper shimming ring 5 ~~(5)~~ is the same as that of the lower shimming ring 6 ~~(6)~~. The inner diameter of shimming ring 6 ~~(6)~~ is larger than that of the shimming ring 5 ~~(5)~~, so ~~that~~ the space that is smaller than the inner diameter of shimming ring 6 ~~(6)~~ and that is under the shimming ring 5 can ~~(5) could~~ be used for fixing the gradient coil 7. The lower end face of the shimming ring 6 ~~(6) is~~ does not ~~lower than~~ extend or project below the lower plane of the transmitting coil 8. Similarly, the two shimming rings of the lower pole plate 4 are located at the position that corresponds ~~is corresponding~~ to the position in the upper plate 2, ~~and such design will not reduce~~ so the respective distances between the upper and lower pole plates 2 and 4, as well as between the two shimming rings 5 and 6, are not reduced, i.e., the openness will not be affected. In Fig. 2, ~~two dark black~~ arrows that show movement horizontally and vertically respectively are used to indicate that the

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shimming ring 6 ~~(6)~~ and the bolts mounted on the first shimming ring 5 ~~(5) and the second shimming ring (6)~~ can be adjusted in these two directions.

Careful consideration ~~on~~ as to the size and position of the second shimming ring 6 ~~(6)~~ will help to improve the magnetic field distribution at the edge and enhance the adjusting effect of the shimming, ~~and meanwhile,~~ but the open space between the upper and lower poles will not be affected.

Fig. 4 shows another method of ~~changing~~ adjusting the ~~uniformity~~ homogeneity of the field strength. Generally, ~~in~~ for a permanent magnet with a field strength ~~over~~ above 0.3T, the field strength at the edge of the pole plate thereof is weaker than ~~that~~ at the center of the pole plate. In order to make the magnetic field of the area between the two pole plates more uniform, the ~~present invention puts forward a method of dividing~~ inventive method divides the magnetic field generating source into several areas, and magnets at different areas have different magnetic energy levels. As an example shown in Fig. 4, the several ~~circular-shape~~ circular-shaped or ~~ring-shape~~ ring-shaped areas on the pole plate of the present invention that are centered at the axis of the pole plate ~~are made to~~ have different magnetic energy levels, wherein the magnetic energy level in the center area is N1, the magnetic energy in the middle area is N2 and the magnetic energy level in the external area is N3 and N1<N2<N3. Also, as shown in Fig. 4, a ~~plurality~~ number of magnets of different magnetic energy levels ~~could~~ can be provided in ~~the~~ a symmetrical manner ~~of being symmetrical~~ along the vertical axis through the center of the pole plate.

Fig. 5 is a longitudinal section of the magnet, and the shadows of different gray levels indicate magnet objects of different magnetic energy levels, which are symmetrical along the center of the magnet. The magnetic energy level at the center area is lowest and magnets nearer the external edge have higher magnetic energy levels. Other magnetic energy levels combination forms ~~could~~ can be derived on the basis of the principle of the present invention according to the non-uniform structure intentionally designed on the pole plate and the characteristics of the magnetic path. ~~Magnetic~~ Each magnetic energy level could be further

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divided into a number of sub-levels ~~plurality of levels~~, and the ordering of the energy ~~level~~ levels is not limited to ~~the manner of increase~~ increasing from the center to the outer edge, and adjustment could be made on the basis of the pole plates and the magnetic path structures of the devices.

~~In addition, as~~ As shown in Fig. 3, another method of uniforming the magnetic energy level of the present invention is to insert a plurality of magnetic bolts at the external edges of the pole plate and the press plate, and the ~~uniformity~~ homogeneity of the field strength is adjusted by changing the magnetic path. As shown in Fig. 3 (and Fig. 1), these magnetic bolts could be arranged symmetrically. However, if the influence of the middle section connecting object of the C-type magnet on the field strength between the two poles or other multi-column plate structures are considered, these bolts could also be arranged in a non-symmetrical way. In the existence of tolerances of manufacturing and assembling of said magnetic resonance imaging equipment, the field strength of the diagnosing area could be adjusted by adjusting these bolts to some extent. The material of the bolts ~~could~~ can be ~~permanent~~ permanently magnetic material or ferromagnetic material and the diameters of the bolts could be either the same or different, but they are preferably the same. The bolts should be arranged symmetrically or near symmetrically, and the number of the bolts should be set according to the strength of the magnetic field and the practical structure, and too many bolts will make the adjusting difficult. It is not difficult for those ordinarily skilled in the art to change and adjust those bolts according to the specific cases to achieve the shimming effect.

The operators could use one or a combination of the above-mentioned methods to achieve better shimming effect.

~~One~~ An advantage of the apparatus and method of the present invention ~~lies in~~ is that the magnet made by the method of the present invention could have field strength higher than 0.3T with higher homogeneity in the scanning area satisfying the requirements. Therefore, the size of the apparatus could be reduced and the cost will be reduced. For example, the specifications of the

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magnet of 0.35T manufactured according to the present invention are as follows: the weight is less than 16 tons, the uniformity of the magnetic field in 36cm sphere is less than 40ppm; and the width of the patient gap is larger than 41cm and the stability of the static magnetic field is <±20Hz/10 minutes.

~~Another advantage of the apparatus and method of the present invention is that since the apparatus could be precisely designed and adjusted, most shimming works could be finished during the processing of manufacturing and assembling of in factory and it is unnecessary to carry out passive shimming at site and thus saves the time for installation.~~

Although modifications and changes may be suggested by those skilled in the art, it is the invention of the inventors to embody within the patent warranted heron all changes and modifications as reasonably and properly come within the scope of their contribution to the art.